
Space Weather Technical Forecast

Issued on Monday, 27 February 2023 at 13:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: G1/Minor to G2/Moderate storms expected, and chance G3/Strong storms 27-28 Feb. R1-R2 Blackouts likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with several C-class flares observed, the largest a C4.5 from sunspot region AR3234 in the northwest quadrant. This region is notably complex and contains a delta spot. AR3229, which has a history of significant activity is now close the northwest limb and has simplified. AR3236 in the southwest quadrant has also simplified and has simplified, losing a delta spot region. The remaining five regions are all simple or fading. A CME has been observed on coronagraph imagery leaving the south of the Sun and this will be analysed to determine if it has an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar wind speeds, as measured by DSCOVR and ACE at L1, started at 450km/s in the presence of a coronal hole high speed stream, but then increased to 600-700km/s at around 26/1800UTC due to the arrival of a CME which left the Sun on 24 Feb. A further increase to 800km/s was observed around 27/1000UTC which may indicate the arrival of a CME which left the Sun on 25 Feb, although this is currently inconclusive. Density increased from average to reach close to 35ppcc around 26/2000UTC and despite decreasing slightly, has remained above average since. Total IMF, Bt, started at moderate levels but reached a strong peak of 21nT at 26/2058UTC before falling back to moderate levels. A second peak of 21nT was then observed at 27/1026UTC. Bz started near neutral or just positive, but then reached a negative peak of -19nT at 26/2056UTC and was then persistently, but moderately negative until a further negative peak of -18nT at 27/1028UTC. Phi angle has been predominantly negative (towards the Sun) with only brief positive rotations. Geomagnetic activity started Unsettled (Kp 3) before rising to G1/Minor (Kp5), then has been G2/ Moderate (Kp 6) storm level from 27/0000UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16, has fallen to from 31ppcc to 2ppcc on a declining trend. Electron flux has been at background or moderate levels. Electron fluence values 2.02e6 integrated pfu at 27/0000UTC.

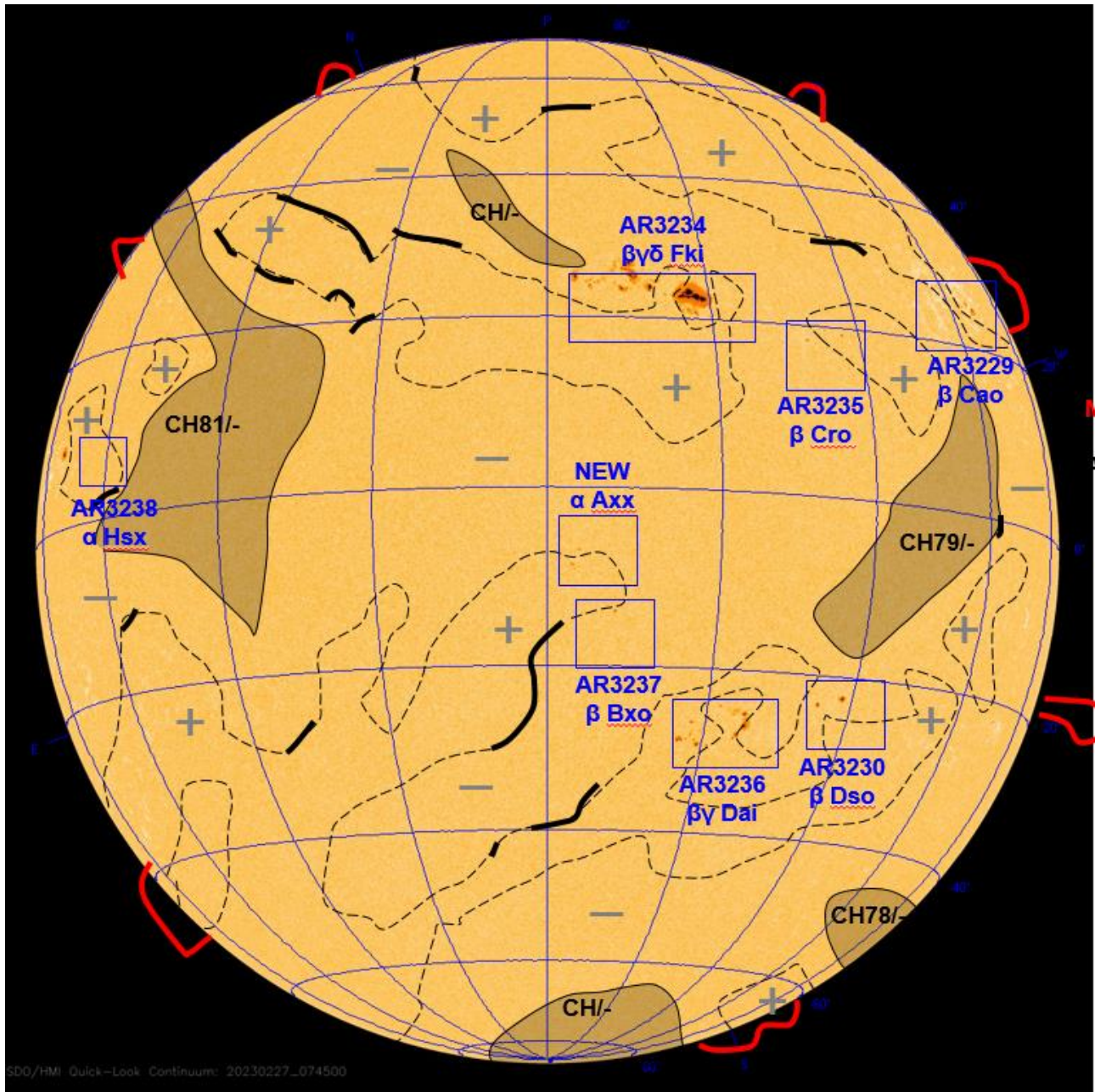
Four-Day Space Weather Forecast Summary

Solar Activity: Low or Moderate activity is expected through the next four days, due to a number of significant sunspot regions on the visible disc. There is also a chance of Strong flares.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 24 Feb is currently affecting the Earth, with a further CME, which erupted on 25 Feb forecast to arrive during 27 Feb. Both CMEs are expected to reach speeds of 600-700km/s at Earth. A coronal hole high speed stream, as a result of CH79/- is also connected with Earth, but the effects and evidence of this are largely masked by the CMEs. The high speed stream from this coronal hole is likely to be around 500km/s, with this expected to wane through 01 and 02 Mar. G1/Minor or G2 /Moderate storms are expected on 27 Feb and into 28 Feb with a chance of G3/Strong storms. There is then a decreasing risk of G1 or G2 storms through 01 and 02 Mar.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 2MeV) is below the S1/Minor storm level, but could increase to S1 level again on 27 Feb due to a further CME arrival. There is then a reducing chance of radiation storms later in the period. High energy electron flux (greater than 2MeV) is expected to remain at background to moderate levels through much of the period, maybe with an upward trend into high values on 01 and 02 Mar. Electron fluence values are also forecast to remain suppressed for much of the period, perhaps increasing towards the active ($1e8$ integrated pfu) threshold by 02 Mar.

Figure 1. Solar Analysis Valid 27/0800UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

A CME which left the Sun on 24 Feb arrived at Earth late on 26 Feb, producing a G2/Moderate Storm. A further CME is forecast to arrive at Earth around 27/2000UTC, although based on recent observations, there is a risk that this has arrived slightly earlier than forecast.

Earth is also under the effects of a coronal hole high speed stream, which connected concurrently with the 24 Feb CME arrival. This is expected to continue to affect the Earth through 27 Feb before declining from 28 Feb, although the actual effects are likely to be masked by the CME arrivals, as the CME is moving faster than the speed of the high speed stream. Speeds could reach 600-700km/s due to the CME with the coronal hole high speed stream reaching speeds of 500km/s.

Geomagnetic activity is expected to reach G1/Minor Storm or G2/Moderate storm levels through 27 Feb, with a chance of G3/Strong storm intervals. This risk is expected to continue into 28 Feb, with a diminishing risk later on 28 Feb. There is a further risk of G1 or G2 storms on 01 March with no further CMEs or coronal hole connections forecast.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	80	70	30	10
Strong	G3	No	30	30	5	1
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
25/2319	Full	NW quadrant	AR3229	940km/s	27/1800UTC -6/+12 hours	Lopsided halo

Figure 2: MOSWOC Enlil and Enlil ensemble indicating CME arrival time. The ensemble shows the spread for the arrival of the CME which adds to the uncertainty.

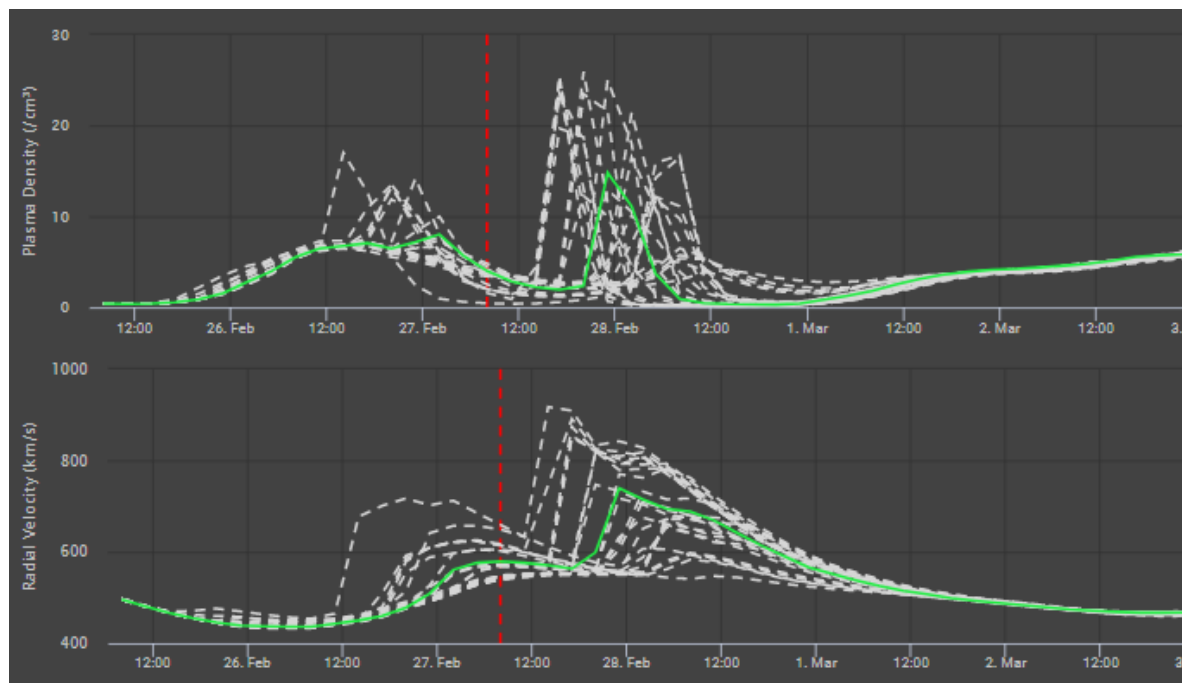
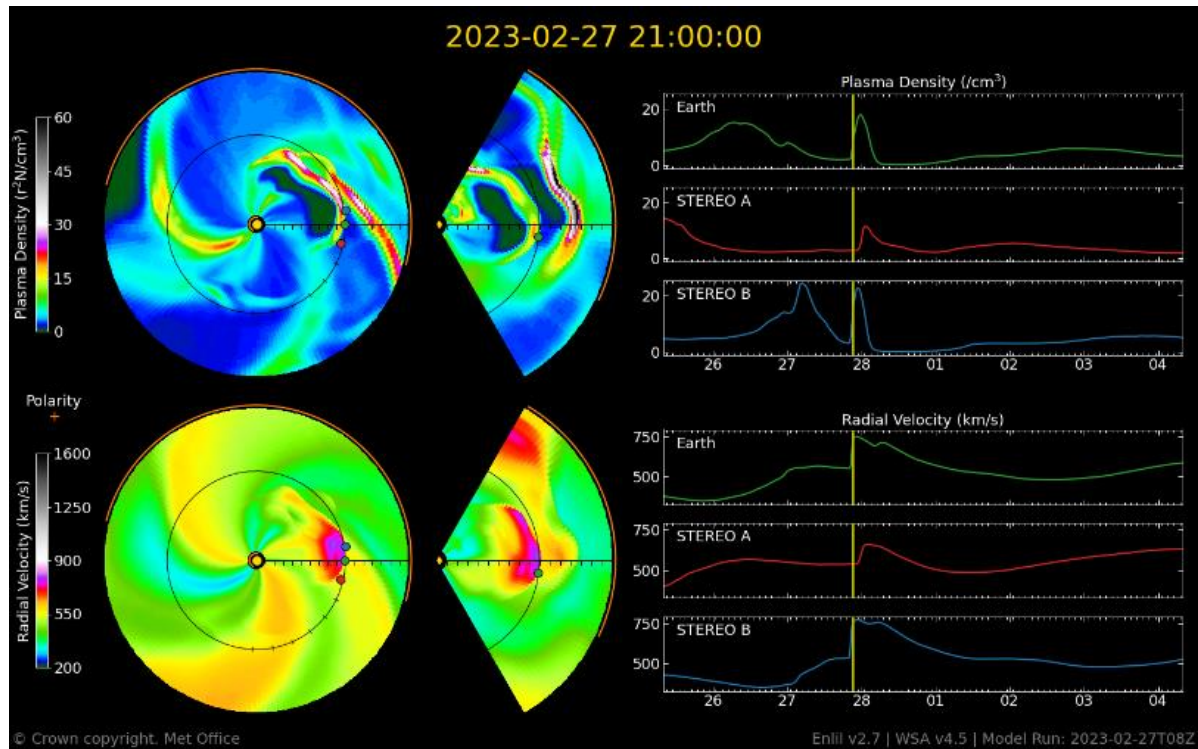
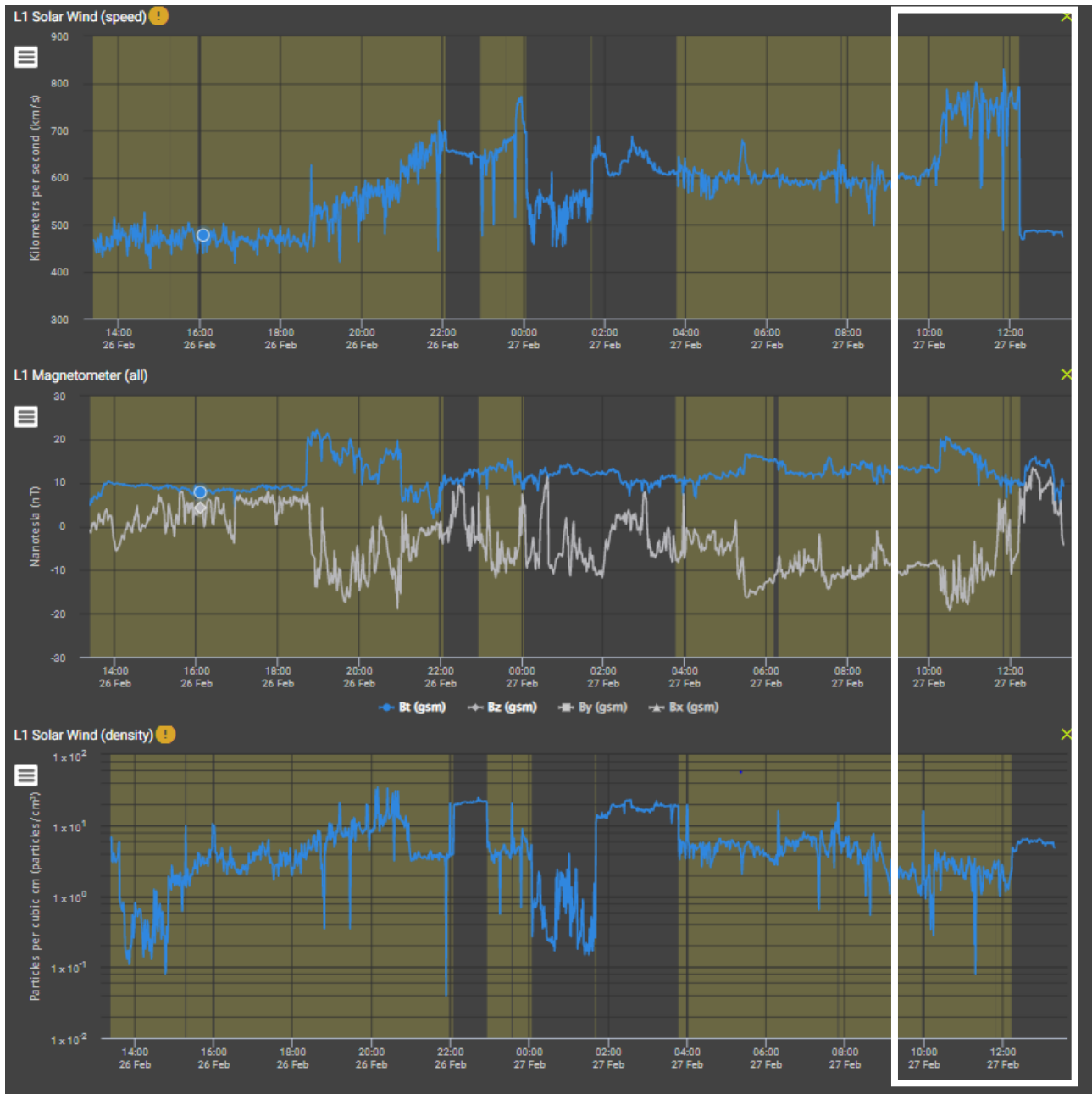




Figure 3: DSCOVR and ACE solar wind parameters. Data is currently inconclusive about the second CME with the potential data indicated.



Radio Blackouts - X-Ray Flares:

There are eight sunspot regions on the visible disc, with the most significant region AR3234 (Fki/ $\beta\gamma\delta$) in the north centre disc. This region has a limited history of significant activity, but carries a notable flare risk. The most active region on the disc is AR3229 (Cao/ β) which is now approaching the northwest limb and is rapidly fading and simplifying. AR3236 (Dai/ β) in the southwest quadrant, has a history of containing a delta region, but has simplified magnetically through the last 24 hours. The presence of both these regions leads a likelihood of M-class flaring through much of the period, with any flares from AR3229 likely to be visible from the far side of the Sun into 01 and 02 Mar. Five remaining regions are either simple or simplifying.

Solar activity is forecast to be mainly Low to Moderate through the next four days, with a very slight chance of Strong activity.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is now below the S1 threshold, as the effects of previous flare and CME declines. There is a risk of a further CME arrival during 27 Feb which could lead to further enhancements. In addition, there are three higher risk sunspot regions in the western hemisphere of the Sun, with any significant flares from these regions likely to produce Earth-directed proton storms.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	Yes	40	30	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) observed at GOES16 has varied between moderate and background levels. This is likely due to the radiation belts being suppressed by a combination of elevated geomagnetic activity and strong solar wind speeds distorting the radiation belts. Speeds and geomagnetic activity are forecast to decrease later in the period, with a risk of a rise in the electron counts towards the end of the period.

Electron fluence is expected to persist well below the Active ($1\text{e}8$ integrated pfu) level for much of the period, with any rise towards the threshold more likely on 01 or 02 Mar. However based on the uncertainty in the timing and effects of possible CME arrivals, the risks are relatively low at this stage.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^8$	No	1	5	20	30
Very Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^9$	No	1	1	1	1